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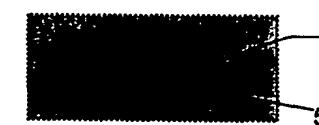
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(54) Title: A FIRE RESISTANT INSULATION MATERIAL

(57) Abstract: An insulation material and a method of manufacturing the insulation material are disclosed. The insulation material includes (a) particles of a combustible insulation material coated with a fire resistant material and/or (b) an open celled foam of the combustible insulation material having internal surfaces coated with the fire resistant material.

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A Fire Resistant Insulation Material

Background of the Invention

5 Field of the Invention

The present invention relates to an insulation material.

10 Description of Prior Art

Lightweight, rigid, homogenous, closed-cell expanded polymeric insulation materials such as expanded or extruded polystyrene foams, rigid polyurethane foam, 15 polyisocyanurate foam and polyethylene foam are inexpensive and have been used widely as insulation in many forms, such as mouldings, boards, etc.

However, polymeric materials that are 20 thermoplastic have a low melting point (for example, polystyrene foam) and nearly all polymeric materials have a low decomposition point compared to inorganic materials. Therefore, expanded polymeric insulation materials are generally unable to resist a fire for 25 long, i.e. half an hour or more, as they would melt and burn and so fail early in a fire.

Open-cell and flexible expanded polymeric insulation materials have also been used as insulation 30 materials. In addition to having the same low fire resistance of closed-cell foamed materials described above, open-cell and flexible foam materials lack rigidity. The lack of rigidity limits the use of these materials in structural applications.

35

A known use of polymeric insulation materials (for example, polyurethane and polyisocyanurate foams)

is to cast and foam the materials between thin facings to make stressed-skin or sandwich panels. A known use of polymeric insulation materials that are not adapted for in-situ foaming (for example, expanded polystyrene or 5 extruded polystyrene foams) is to laminate the materials to one or more thin facings to make similar stressed-skin sandwich panels. Due to their thin or lightweight components, sandwich panels are also light but have very high strength due to the stressed-skin configuration and 10 can be used to extend across large spans of 30m and more, with few or no intermediate supports. Sandwich panels are popularly used as walls, claddings, partitions, ceilings and roofs of buildings. Even though their surface flame spread rating follows that of 15 the metal facing material, sandwich panels are unable to resist a fire for long, as this is dependent on the fire resistance of the core insulation material.

Another application of polymeric insulation 20 materials, especially of expanded polystyrene foam, in the building industry is as moulded form-work elements (also known as insulating concrete formwalls) that are left in place after completing the construction of a wall or other building component as an insulation layer. 25 Generally, form-work elements define a cavity wall inside a block of foam or between two blocks of foam secured by tie mechanisms across the cavity. The cavities are filled with concrete at intervals or in their entirety. The facing foam material is then 30 finished with a building material in sheet form or by a lath and plaster finish. This product has a better fire resistance due to the thicker facing materials used. However, if a fire occurs and enters the insulation core, there would be the same consequences of foam 35 melting and burning as mentioned above.

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In situations in which the low fire resistance of polymeric foam insulation materials cannot be accepted, inorganic materials that are incombustible are used instead of these materials. Materials such as 5 calcium silicate, foamed glass and mineral rock fibre slabs are able to resist a fire for a considerable length of time, e.g. 1 to 4 hours.

However, these incombustible materials usually 10 are not as good insulators as polymeric foams and are heavy. For example, the density of foam glass is 136kg/m³ and of mineral rock fibre is 80 to 170kg/m³ whereas polymeric foams can be as light as 16 kg/m³. These incombustible materials are heavy and therefore 15 difficult to handle for construction and have to be supplied in short lengths (for example, 2.4m) and, if used in a panel, have to be in short spans or used with structural supports at close intervals. There are 20 lightweight incombustible materials with good insulation, like fibreglass, also known as "glasswool", but these materials do not have the strength and shear resistance for load bearing such as in a stressed-skin panel. Panels with honeycomb cores are lightweight but 25 do not insulate well and are not fire resistant, although they do not add to a fire load if they are made of incombustible materials, e.g. metal facings and metal honeycomb core.

Some inorganic insulating materials are 30 difficult to handle during installation and maintenance as they are brittle and break off in small pieces and cause dust contamination and, in the case of short fibre mineral wools, cause itchiness.

35 Aerated concrete blocks have densities from 600 to 850 kg/m³. These blocks are suitable for conventional

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walls but are too heavy for use as the core of a light-weight stressed-skin panel.

In the 1970s BASF introduced Styropor Beton,
5 polystyrene foam pellets embedded in a matrix of cement. This material is highly fire resistant due to the presence of the cement matrix. The product can be poured in-situ as a flooring material. However, it has
10 a high density of the order 500 to 600 kg/m³ and therefore is unsuitable for lightweight stressed-skin panels.

In the 1960s BASF introduced BASF HT foam,
15 polystyrene foam pellets embedded in a matrix of siliceous inorganic binder, that formed a very hard material. This material has good fire resistance. However the high density of 155 to 165kg/m³ would make a heavy stressed-skin panel that needs more structural support.

20

In US patent 5,516,552 Bontrager et. al. disclose a fire resistant polystyrene board made by applying a fire resistant composition onto the surface of expanded or extruded polystyrene foam boards and
25 impregnating the body of these boards with a sodium silicate and hydrated alumina mixture via recesses in the boards. Although this invention attempted to disperse the fire resistant composition by means of wetting agents, it is not possible to uniformly coat
30 every section of the body of the insulation material since the coating only flows through the recesses and the interstices. Therefore, the coating is irregular and incomplete and has areas that are left uncoated and unprotected.

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In 1998 the International Association of Cold Storage Contractors (IACSC), European Division,

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published guidelines for the construction of cold stores using insulating panels. Particular emphasis was given to the vulnerability of lightweight polymeric panels in a fire. The guidelines include suggestions to compensate 5 for the shortcomings of lightweight polymeric panels, particularly in relation to endangering the lives of fire fighters entering a building to fight a fire.

10 The use of non-combustible panels was considered, but the guidelines noted that the use of lightweight polymeric panels continued to be of importance to users, manufacturers and contractors due to its low cost, proven performance and technical advantages. Consequently, a substantial portion of the 15 guidelines deals with designs of joints and supports of lightweight polymeric panels to prevent early collapse of the panels in a fire.

20 These designs were mainly in the direction of securing panel skins to prevent the skins separating and falling when the insulation materials or the glue had been destroyed by fire and applying intumescent sealant to retard the penetration of fire at the joints between panels. However, although the measures made the panels 25 safer to use by preventing the delaminated panel skins from falling and the joints from opening in a fire, none of these measures increase the fire resistance of the panels.

30 The guidelines were the outcome of contributions of manufacturers, contractors, industry users and fire authorities and therefore represent the practical state of the art at that time.

35 In subsequent reviews by the IACSC in 2000 and 2001 and in additional publications by the IFPO and the British Home Office it can be seen that, while fire

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fighters appreciated and approved the added safety measures, insurers were not satisfied with the poor fire resistance of panels made with polymeric insulation materials, as buildings using these materials were 5 usually badly damaged in fires. In order to press the point, insurers described such buildings as buildings "on fire" and not buildings "in a fire". The insurers pressed for the use of panels with incombustible cores. Industry users, manufacturers and contractors however 10 were disinclined to adopt that measure due to the higher cost of panels with incombustible and heavy cores and technical problems known to be associated with their use. Technical problems include by way of example extensive moisture damage should the vapour barrier of a 15 panel with mineral fibre insulation be breached and the ease of damage from foot traffic when it is used as a ceiling.

Although the problems enumerated by the IACSC 20 specifically applied to the cold storage industry, the problems are equally applicable in other situations where insulating panels are used to maintain a temperature and humidity zone, for example, in clean rooms, wall claddings, partitions, ceiling and roofs for 25 factories.

The guidelines of the IACSC recognise the problems associated with the use of polymeric insulation materials in panels. However, the tone and context of 30 the follow-up reviews and other independent publications by fire authorities highlight an urgent need to find solutions to these problems if polymeric insulation materials are to be continued to be used in panels.

Summary of the Invention

According to the present invention there is provided an insulation material that includes (a) 5 particles of a combustible insulation material coated with a fire resistant material and/or (b) an open celled foam of the combustible insulation material having internal surfaces coated with the fire resistant material.

10

The term "particles" is understood herein to include pellets.

15 The particles may be a regular shape or an irregular shape.

Regular shape particles include, by way of example, spherical and rod-like shape particles.

20

Preferably a major dimension of the particles is less than 25mm.

More preferably the major dimension of the particles is less than 20mm.

25

It is preferred particularly that the major dimension of the particles be 2-15mm.

30

Preferably the insulation material includes coated particles bonded together by a binder material.

Preferably the binder material at least substantially fills the interstices between coated particles.

35

The binder material may be the coating material.

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Preferably the particles are at least substantially encapsulated by the fire resistant material.

5

Preferably the particles also include a fire retardant material.

10 The combustible insulation material may be any suitable material.

For example, the combustible insulation material may be a suitable polymeric material.

15 Preferably the particles of combustible insulation material are pre-foamed pellets of a polymeric material, such as polystyrene of a fire retardant grade.

20 The particles may also be obtained by way of example by grinding and recycling formed products, such as foamed polymeric products, for example, expanded polystyrene foam from building boards, recovered panels, packaging, foam containers, extruded polystyrene foam, 25 polyurethane foam, phenolic foam, etc.

Many other materials can also be used as the source of the particles, including natural materials e.g. cork granules, wood chips, rice husks, etc.

30

Preferably the coating of the fire resistant material is applied to the particles at a thickness corresponding to the degree of fire resistance that is desired.

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Preferably the combustible insulation material for the open cell foam is polyimide foam or melamine foam.

5 The fire resistant coating material is preferably an intumescent material, such as FX-100, Albi Cote FRL, NoFire A-18, or a mixture of fire resistant materials.

10 By way of example, the fire resistant coating material may include aluminium trihydrate, a char promoter (such as Chlorez and Holdaresin), a carbon donor (such as dipentaerytritol), an acid donor (such as ammonium polyphosphate), a propellant (such as 15 melamine), a binder (such as polyvinyl acetate and polyvinyl ester), an exfoliating graphite, hydrated alkali metal silicates (such as sodium silicate), a silicate insolubiliser (such as sodium fluorosilicate), and a surfactant.

20 Preferably the intumescent coating material is selected according to the properties desired, such as the temperature of activation, stiffness of the intumescence, and the pressure generated during 25 expansion. Generally, a lower initiation temperature, greater stiffness and lower expansion pressure is preferred.

30 According to the present invention there is also provided a method of manufacturing an insulation material that includes coating particles of combustible insulation material with a fire resistant material.

35 Preferably the method includes coating the particles so that the particles are at least substantially encapsulated with the fire resistant material.

Preferably the particles also include a fire retardant material.

5 The method may include forming free-flowing loose-fill agglomerates of the coated particles.

10 Preferably the method includes forming free-flowing loose fill agglomerates of the coated particles by mixing the coated particles with a binder material 10 that sets to hold the particles together.

15 The method may also include forming panels or other shaped products from the coated particles that may be used, for instance, in building construction or as building construction elements.

20 Preferably the method includes forming panels or other shaped products by mixing the coated particles with a binder material.

25 Preferably the binder material at least substantially fills the interstices between coated particles in the products.

The binder material may be the coating material.

30 Preferably the method includes coating particles of combustible insulation material with the fire resistant material by forming a coating of the fire resistant material on the particles and thereafter curing the fire resistant material.

35 Preferably the curing temperature is below the service temperature of the combustible insulation

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material, particularly in situations in which the combustible insulation material is a polymeric material.

In situations in which the fire resistant 5 material includes an intumescent material, preferably the curing temperature is below the activation temperature of the intumescent material.

Typically, the curing temperature is 50-70°C in 10 situations in which the combustible insulation material is a polymeric material and the fire resistant material includes an intumescent material. The service temperatures of preferred polymeric materials are 80-300°C. The activation temperatures of preferred 15 intumescent materials are 100-260°C. The activation temperatures of particularly preferred intumescent materials are 100-200°C.

The step of coating the particles with the fire 20 resistant material so that the particles are at least substantially encapsulated in the fire resistant material in effect encases each particle in a fire resistant cocoon. Even if the particles are made of a combustible insulation material such as a thermoplastic 25 material that melts in a fire, the encapsulation of the particles contains and retards the release of the combustible melt and thereby reduces the rate the fire develops and spreads. Further the cocoon retards the release of sooty and toxic combustion by-products.

30

If a fire retardant material has been incorporated into the particles, the encapsulation of the particles retains the gases released when the fire retardant material is activated by a fire and thereby 35 enhance the smothering effect of the fire retardant.

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Preferably the insulation material includes a uniform distribution of coated particles, whereby the insulation material can resist a fire coming from any direction.

5

Further, a uniform distribution of coated particles allows the insulation material to be freely cut and reshaped after manufacture without reducing the degree of fire protection.

10

The insulation material when used directly (as agglomerated particles) or indirectly (i.e. in a formed shape) can also be bonded to one or more sides of thin metal facings or non-metal facings to make an insulating panel. Even if the particles chosen for the insulation material are combustible, the insulating panel made from the insulation material would have a degree of fire resistance not found in the original, uncoated particles. Such a panel is a solution to the concerns of agencies such as the IACSC that panels made from polymeric insulation materials burn rapidly and make a significant contribution to a fire.

25 The method may include manufacturing the insulation material from particles having a range of different particle sizes.

30 The method may include manufacturing the insulation material by coating the particles with a range of different coating thicknesses.

35 The method may include manufacturing the insulation material with layers of different sized particles and/or different coating thicknesses, for example, so that the insulation and fire resistance properties of the insulation material varies through its cross section.

For example, the insulation material may have smaller particles with a thicker fire resistant coating located near the surface of the material, where a fire 5 can be expected to impinge on it, and larger particles with a thinner coating located in the interior where more insulation and less fire protection is required.

The above-described means make it possible to 10 engineer or to optimise the use of materials to make the insulation material stronger near the surfaces and, if used in a sandwich panel, to give it a greater load carrying capacity. Likewise, the degree of fire protection can be engineered or optimised by having more 15 of the fire resistant material elements of the panels, i.e. the type of particles, size, fire resistant coating and binder, disposed near the surfaces where a fire is most likely to be encountered.

20 The method may include manufacturing the insulation material from particles of several different insulation materials, whereby the properties and cost of the insulation material can be controlled in ways that are not possible with an article made of a homogenous 25 material. An example of such an insulation material is one in which combustible insulation materials are combined with incombustible insulation materials.

30 By way of particular example, one such insulation material includes an outermost layer of an incombustible insulation material such as perlite or vermiculite to enhance the fire resistance of the insulation material, the degree of which can be varied by changing the thickness of the incombustible layer.

35

In another example, the cost can be reduced by the use of lighter particles towards the centre of an

insulation material as at this point the tensile and compressive forces are less and do not require a strong material.

5 Another example of how cost can be lowered is the use of particles of recycled insulation materials. In the prior art, recycled materials cannot be mixed into a fresh rigid polyurethane foam mixture and there is a limit to the amount of recycled material that can
10 be mixed with fresh polystyrene foam material. However, in this invention, all of the particles can be recycled insulation materials.

15 The coating materials for the particles and/or the binder materials that bind the particles together may have water-proofing and/or vapor-proofing properties so that the insulation material has water and/or vapor resistance. It is known that particles of combustible insulation materials tend to permit some transmission of
20 water vapour and, depending on the material, may also absorb water. In this invention, the coating materials and the binder material contribute to resisting vapor and water ingress. This is important as insulation materials are frequently used in situations that are
25 exposed to moisture condensation or water ingress. Even when such insulation materials include metal facings, the joint seals may fail or may not be present, whereby moisture and water ingress will quickly destroy the insulation property of the panel. This invention is a
30 means of substantially nullifying such moisture and water ingress.

35 The insulation material may make it possible to include mechanically weak materials in a structural panel, for example, phenolic foam, which have good fire resistance but are unsuitable to be used as a structural panel because the materials are friable and easily

delaminate when mechanically stressed. In this invention such weak materials can be used in a panel if they are reduced to particles and encapsulated. By this means, the weakness of material is isolated and is also 5 substantially compensated by the extensive matrix of coatings/binders that provide cohesion and mechanical strength.

The coating material and/or the binder material 10 of the insulation material may include fibre reinforcement that improves the mechanical properties of the insulation material. For example, polypropylene fibres provide stronger mechanical strength, particularly in shear and tension, and glass or ceramic 15 fibres, such as Nomex fibres or Kevlar fibres, or mineral fibres enhance fire resistance and mechanical strength.

According to the present invention there is 20 also provided a method of manufacturing an insulation material that includes coating an open celled foam of a combustible insulation material with a material that is fire resistant and contributes to the rigidity of the insulation material.

25

Preferably the method includes coating the open celled foam with the fire resistant material by forming a coating of the fire resistant material on the open celled foam and thereafter curing the fire resistant 30 material.

Preferably the curing temperature is below the service temperature of the combustible insulation material, particularly in situations in which the 35 combustible insulation material is a polymeric material.

In situations in which the fire resistant material includes an intumescent material, preferably the curing temperature is below the activation temperature of the intumescent material.

5

Typically, the curing temperature is 50-70°C in situations in which the combustible insulation material is a polymeric material and the fire resistant material includes an intumescent material. The service 10 temperatures of preferred polymeric materials are 80-300°C. The activation temperatures of preferred intumescent materials are 100-260°C. The activation temperatures of particularly preferred intumescent materials are 100-200°C.

15

Preferably the method includes coating the open celled foam by impregnating the foam with the fire resistant material.

20

The open celled foam may be readily impregnated by any suitable method. By way of example, the open celled foam may be readily impregnated by using a solution, a gel, or a dispersion of the fire resistant material and immersing, spraying, pouring, or otherwise 25 contacting the material with the open celled foam, thereafter removing excess material by squeezing, draining, or spinning actions, and thereafter drying/curing the coating. This method may be repeated as required to build up the thickness of the coating.

30

The open cell foam structure may be manufactured by any suitable means.

35 Preferably the insulation material is suitable for structural applications.

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Preferably the fire resistant material is selected so that the insulation material has sufficient rigidity for structural applications.

5 Preferably the fire resistant material is sodium silicate or an intumescent material.

The combustible insulation material may be any suitable material.

10 Examples of suitable combustible insulation materials include polyimide foam and melamine foam.

15 The applicant has found in experimental work that melamine foam is a particularly suitable combustible insulation material.

20 The melamine foam tested by the applicant was a flexible material with open cells. The foam structure comprised a network of interconnected rods. Usually, such a flexible material would not be suitable for structural applications.

25 The applicant impregnated the melamine foam with sodium silicate solution and/or intumescent fire resistant coating material. The impregnated melamine foam had considerably improved rigidity and fire resistance.

30 According to the present invention there is provided a product that includes the above-described insulation material.

Description of the Drawings

Figs. 1 to 13 are side elevations of preferred embodiments of insulation materials in accordance with 5 the present invention.

Description of the Preferred Embodiments

Each of the preferred embodiments of the 10 insulation material illustrated in the figures includes particles of a combustible insulation material that are coated with a fire resistant material.

The insulation material may be in the form of 15 loose-fill, i.e. free flowing, agglomerates of coated particles and a binder material.

The insulation material may also be shaped 20 products of the insulation material. The shaped products, of regular or irregular shape, may be formed by way of example from the above-described particles and/or agglomerates.

(a) Fig.1 illustrates one embodiment of a product 25 that includes coated particles and binder material that are formed on a free-form basis an agglomerate 3 of the coated particles and binder material in the shape shown in the figure. The agglomerate can be cut, shaped, drilled and generally handled like conventional building 30 materials.

(b) Figs. 2, 4 and 6 illustrate embodiments in 35 which the coated particles and binder material are formed into products such as boards 5, cylinders 7, curved elements 9, or any other profiled shapes 11. The products can be cut, shaped, drilled and fixed and generally handled like conventional building material.

(c) Figs. 3, 5 and 7 illustrate embodiments of products that include a core 13 of coated particles and binder material and a layer 15 of facing materials such as sheet metal on one or more exposed surfaces of the core. These products, namely stressed-skin or sandwich panels for engineering or construction use, may be manufactured by casting coated particles and binder into a cavity between separated facing sheets that are kept apart in a jig. The facing sheets can be flat, curved or profiled steel, aluminium or stainless steel, etc, or the facing sheets may be non-metal facings such as fibreglass, fiber-reinforced cement or calcium silicate, etc. The binder material is chosen to react chemically, for example, one-component moisture-cured polyurethane, or a 2-component polyurethane foam. These products may also be manufactured by adhering thin facing sheets to the products shown in Figs. 2, 4 and 6 respectively. The facing sheets can be metal, such as unpainted or painted galvanized steel, aluminium or stainless steel, etc, or the facing sheets may be non-metal facings such as fibreglass, fiber-reinforced cement or calcium silicate, etc.

(d) Fig. 8 illustrates an embodiment of products that include non-homogenous cores formed from series of layers 17, 19 of coated particles of different sizes and/or density and/or type of combustible insulation material and binder. For example, the layers 17 nearer the surfaces can be filled with particles that are smaller and/or the particles can have a thicker coating of intumescent material or a coating having other desired properties. In the centre of the embodiment the particles may be larger and/or have thinner coatings. These centrally placed particles may be all of one size or alternatively may be progressively larger and/or with progressively thinner coatings towards the surfaces. In

yet another possibility of this non-homogenous embodiment, incombustible particles, such as, perlite or vermiculite and/or with a more fire-resistant coating, for instance, can be placed beneath the surfaces, to 5 further enhance the resistance to a fire. In yet another possibility, hollow microspheres of glass or ceramic can be incorporated in the binder material as a filler to reduce the interstices between particulates and thereby improve the insulation and also the fire resistance. In 10 yet another possibility, expandable graphite particles, which when exposed to high temperatures intumesce to form a heat barrier, can be incorporated in the binder material to further improve the fire resistance.

15 (e) Figure 9 illustrates an embodiment of products that include non-homogenous cores formed from a series of layers 17, 19 of coated particles of different sizes and or density and or type of combustible insulation material and binder material and one or more layers 21 20 of facing materials such as sheet metal on one or more exposed surfaces of the cores. The product may include the features of the Figure 8 product described in subparagraph (d) above. In addition, hollow microspheres of glass or ceramic can be incorporated into an adhesive 25 layer that secures the facings to the core to improve the fire resistance at these boundaries. Furthermore, expandable graphite particles can be incorporated into the adhesive layer that secures the facings to the core to improve the fire resistance at these boundaries. In 30 yet another possibility, this arrangement can also include stronger, load bearing particles, for example, of extruded polystyrene foam, beneath the facings to resist compressive buckling of the panels.

35 (f) In another embodiment, there may be non-combustible insulation materials. While these materials do not need additional fire resistance provided by a

coating of a fire resistant material, the materials can benefit from other properties that can be provided by a coating, such as, water-proofness or vapour-proofness. Being able to resist condensation and moisture ingress,
5 preserves the insulating property of the particles.

(g) Figs. 10 and 11 illustrate embodiments of products that are in the form of a board or panel that include a layer 23 or layers 23 (not shown) of material
10 of heavier mass than the coated particles of incombustible insulation material and binder material that form other layers 17 of the product. The product shown in figure 11 also has outer layers 25 of facing materials. The material may be thin lead sheet or lead-filled sound dampener sheet that acts as a sound transmission barrier. The preferred arrangement is for the heavy sheet to be located in the centre of the article.

(h) Figs. 12 and 13 illustrate embodiments of products that are in the form of vacuum insulation panels that include outer skins 31 of thin gas barrier material and inner cores 33 of coated particles (Fig. 12) or an open cell structure coated with fire resistant material (Fig. 13). The products have rigid, porous and fire resistant cores which allows the rapid evacuation of air. The light weight rigid particles or rigid reinforced cell networks are capable of withstanding the vacuum pressure without collapse. The products may be in any suitable shape. In particular, the use of the above-described cores 33 makes it possible to manufacture shaped forms, such as container assemblies, and then apply suitable outer skins to the shaped cores 33.

35

Examples of use (or Preferred Methods of Manufacture)

Application and Uses for the Present Invention

In one method the particles are first coated with a liquid fire-resistant material. There are many 5 coating options, for example, stirring or tumbling a mixture of the two, spraying the coating onto the particles, spraying the coating onto the particles in a fluidised bed, percolation, immersion, or by any other means that can coat the particles thoroughly.

10

Following this, the coated particles are poured into a single charge mould. More of the coating material is introduced to fill the interstices and to bind the coated particles to each other. The 15 coating/binder is set and dried in a number of ways, for example, by externally applied heat or dielectric or radio-frequency heating or hot air passing through the mix. The mould is envisaged to have a lid for charging the mix into it and with sides that can be opened so 20 that product can be taken out. It is also envisaged that the contents of the mould be partially compressed by one of the sides moving in to reduce the mould volume after it is closed, to induce a better contact between the particles and to reduce the voids that are between 25 them.

In another method, the coated particles are dried before they are charged into a mould. In this instance the same intumescent coating or different fire- 30 resistant material may be selected as the binder, for example, to provide a greater stiffness or a greater flexibility of the matrix as is desired. The binding coating need not be an intumescent material, although this is the preferred material. After this, the mix is 35 processed as described in the preceding paragraph.

In another method, the coated particles are dried before they are charged into a mould. In this instance, a polyurethane or polyisocyanurate foamable mix is introduced into the mould as a filler and binder.

5 These materials are formulated to react, foam and polymerize rapidly, to fill the interstices and bind the particulates. However as these filler/binder materials are combustible, the particles are pre-coated to a greater thickness in order to compensate for the extra

10 combustible material load in the interstices that has to be protected.

In another method, the mould can have a continuous feed end and a continuous discharge end.

15 Fresh material is introduced at one end and cured material is continuously extruded from the opposite end, pushed by the pressure of the incoming fresh material. The coating/ binding material is set and dried in a number of ways, for example, by externally applied heat

20 or by dielectric or radio-frequency heating or by hot air passing through the mix as the material traverses the length of this moulding station.

Many modifications may be made to the preferred

25 embodiments of the present invention described above without departing from the spirit and scope of the invention.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An insulation material that includes (a) particles of a combustible insulation material coated with a fire resistant material and/or (b) an open celled foam of the combustible insulation material having internal surfaces coated with the fire resistant material.
- 10 2. The insulation material defined in claim 1 includes coated particles that are bonded together with a binder material.
- 15 3. The insulation material defined in claim 2 wherein the binder material at least substantially fills interstices between coated particles.
- 20 4. The insulation material defined in claim 3 wherein the binder material is the coating material.
- 25 5. The insulation material defined in any one of the preceding claims wherein the particles are at least substantially encapsulated by the fire resistant material.
- 30 6. The insulation material defined in any one of the preceding claims wherein the particles include a fire retardant material.
- 35 7. The insulation material defined in any one of the preceding claims wherein the coating material for the particles and/or the binder material that binds the particles together have water-proofing and/or vapor-proofing properties.

8. The insulation material defined in any one of
the preceding claims wherein the coating
material and/or the binder material include
fibre reinforcement that improves the
mechanical properties of the insulation
material.
9. The insulation material defined in any one of
the preceding claims wherein the combustible
insulation material includes recycled
insulation material.
10. A method of manufacturing an insulation
material that includes coating particles of
combustible insulation material with a fire
resistant material.
11. The method defined in claim 10 includes
coating the particles so that the particles
are at least substantially encapsulated with
the fire resistant material.
12. The method defined in claim 10 or claim 11
includes—forming free-flowing loose-fill
agglomerates of the coated particles.
13. The method defined in claim 10 or claim 11
includes forming free-flowing loose-fill
agglomerates of the coated particles and with
a binder material that sets to hold the
particles together.
14. The method defined in claim 10 or claim 11
includes forming panels or other shaped
products from the coated particles.

15. The method defined in claim 14 includes forming panels or other shaped products by mixing the coated particles with a binder material.

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16. The method defined in claim 15 wherein the binder material at least substantially fills interstices between coated particles in the products.

10

17. The method defined in any one of claims 14 to 16 includes forming panels or other shaped products having a uniform distribution of coated particles, whereby the insulation material can resist a fire coming from any direction.

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18. The method defined in any one of claims 14 to 17 includes applying metal facings or non-metal facings to the panels or other shaped products.

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19. The method defined in any one of claims 10 to 17 includes manufacturing the insulation material from particles having a range of different particle sizes.

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20. The method defined in any one of claims 10 to 19 includes manufacturing the insulation material by coating the particles with a range of different coating thicknesses.

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21. The method defined in any one of claims 10 to 20 includes manufacturing the insulation material with layers of different sized particles and/or different coating thicknesses so that the insulation and fire resistance

properties of the insulation material varies through its cross section.

22. The method defined in claim 21 includes manufacturing the insulation material with smaller particles and a thicker fire resistant coating located near the surfaces of the material and larger particles and a thinner coating located in the interior.
- 5
- 10
23. The method defined in claim 21 or claim 22 includes forming the layers with a binder material to hold the particles together within a layer and to hold the layers together.
- 15
24. The method defined in claim 23 includes incorporating microspheres of glass or ceramic material (a) into the adhesive layer binding the facings to the insulation particles to improve the fire resistance at that boundary and/or (b) in the binder material as a filler to reduce the interstices between particles and thereby improve the insulation and the fire resistance.
- 20
- 25
25. The method defined in claim 24 wherein the microspheres are hollow.
26. The method defined in any one of claims 10 to 30 includes manufacturing the insulation material from particles of different insulation materials.
- 35
27. The method defined in claim 26 includes manufacturing the insulation material from combustible insulation materials and incombustible insulation materials.

28. A method of manufacturing an insulation material that includes coating an open celled foam of a combustible insulation material with a material that is fire resistant and contributes to the rigidity of the insulation material.

5
10 29. The method defined in claim 28 includes coating the open celled foam by impregnating the foam with the fire resistant material.

15 30. The method defined in claim 28 or claim 29 wherein the insulation material is suitable for structural applications.

20 31. The method defined in any one of claims 28 to 30 wherein the fire resistant material is sodium silicate or an intumescence material.

32. A product that includes the insulation material defined in any one of claims 1 to 9.

1/3

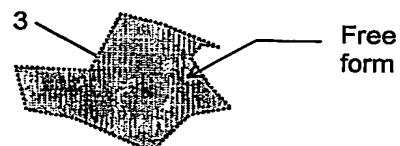
**Compositions
without facings**

Fig 1

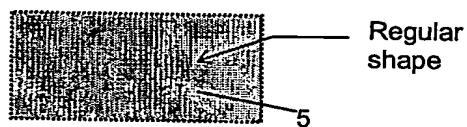


Fig 2



Fig 4

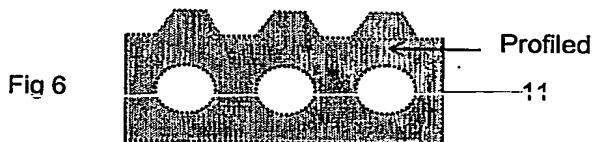


Fig 6

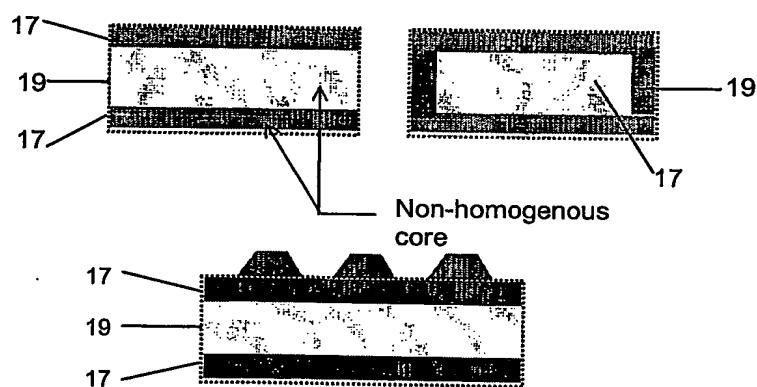


Fig 8

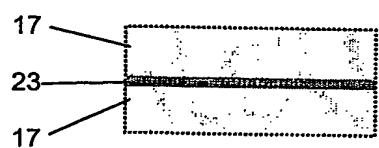


Fig 10

Compositions with facings

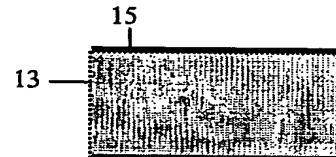


Fig 3

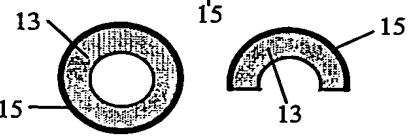


Fig 5

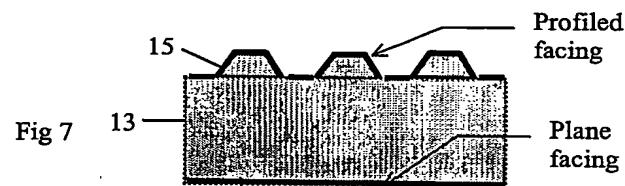


Fig 7

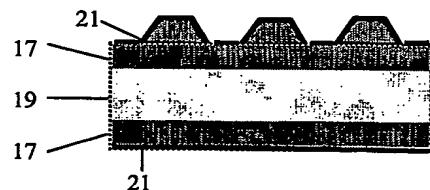
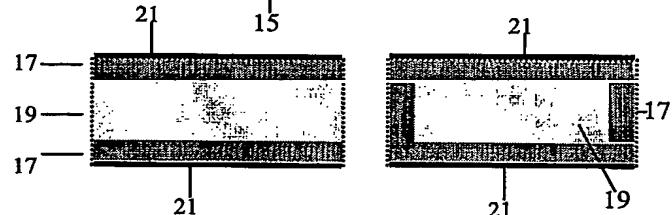


Fig 9

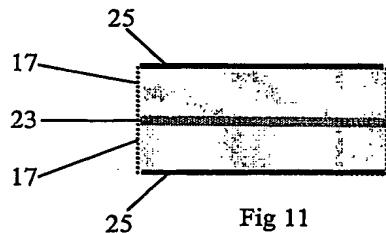


Fig 11

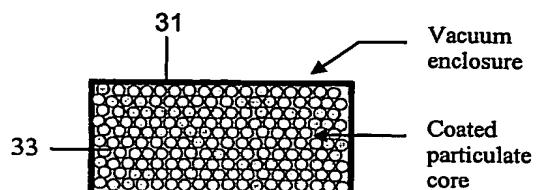
Compositions with vacuum enclosure

Fig 12

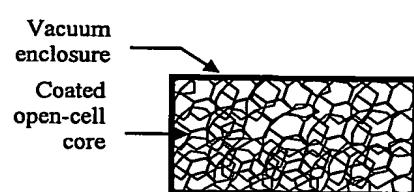


Fig 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG02/00109

A. CLASSIFICATION OF SUBJECT MATTER

Int. CL. 7: E04B 1/94, C09D 175/04, C09D 175/06, C09D 5/18, C09D 1/00, C09D 1/02, C09D 185/02, C09K 21/02, C09K 21/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Derwent WPAT, Japio; Chemical Abstracts CAPLUS; Keywords: insulation, fire, polyurethane, polyisocyanurate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4292214 A (BLOUNT) 29 September 1981; see 'Summary of the invention' in particular.	1-32
X	US 4931481 A (ADAM ET AL.) 5 June 1990; see 'Summary of the invention' in particular.	1-23, 26-32
X	US 4107376 A (ISHIKAWA) 15 August 1978; see the abstract in particular.	1-24, 26-32

Further documents are listed in the continuation of Box C

See patent family annex

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 2 September 2002	Date of mailing of the international search report 11 SEP 2002
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer DAVID HENNESSY Telephone No : (02) 6283 2255

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG02/00109

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4172744 A (ISHIKAWA) 30 October 1979; see column 1, line 62-column 5, line 25.	1-32
X	GB 1158591 A (REDFARN, C.A.) 16 July 1969; see the whole document.	1-23, 26-32
X	WO 01/72863 A1 (APACHE PRODUCTS COMPANY) 4 October 2001; see the abstract and claims in particular.	1-23, 26-32
X	EP 0224945 A1 (SHELL INTERNATIONALE RESEARCH MAATSHAPPIJ B.V.) 10 June 1987; see the abstract and example in particular.	1, 7, 28-32
X	EP 0942107 A2 (SALAMANDER INDUSTRIE-PRODUKTE GMBH) 15 Spetember 1999; see the abstract and claims in particular.	1-24, 26-32
X	WO 94/24226 A1 (CHEMISCHE FABRIK GRUNAU GMBH) 27 October 1994; see the abstract in particular.	1-23, 26-32
X	DE 19910257 A1 (E.SCHWENK DAMMTECHNIK GMBH & CO KG) 21 September 2000; see the abstract in particular.	1-23, 26-32
X	DE 3115456 A1 (STEFFENS, J.) 30 December 1982; see the whole document.	1-24, 26-32

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SG02/00109

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	4292214	AT	13542	AU	63940/80	CA	1162678
		DE	3041424	DE	3170690	DK	198081
		EP	26204	EP	52097	EP	39666
		GB	2061279	NL	8020125	NO	811499
		SE	8008615	US	3956466	US	3979362
		US	397782	US	4072637	US	3993737
		US	4020259	US	4033935	US	4097424
		US	4036787	US	4011253	US	4086190
		US	4069391	US	4089883	US	4169930
		US	4169930	US	4100112	US	4113693
		US	4089840	US	4088632	US	4087407
		US	4104456	US	4138421	US	4153768
		US	4107140	US	4115635	US	4157438
		US	4201702	US	4159369	US	4153764
		US	4139549	US	4205155	US	4185147
		US	4215203	US	4271284	US	4211848
		US	4226982	US	4220757	US	4304877
		US	4235974	US	4241194	US	4242497
		US	4243757	US	4247657	US	4283311
		US	4273908	US	4260696	US	4292413
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		US	4383089	US	4382136	US	4359548
		US	4376171	US	4377674	US	4380592

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/SG02/00109

		WO	8002142		WO	8103332		
US	4931481	CA	1286840		DE	3632915	EP	265650
		JP	63117029					
US	4107376	AR	208947		AT	164076	AT	358827
		AT	358828		AT	359289	AT	7108979
		AU	5037/93		AU	11652/76	BR	7601355
		CA	1075096		CH	625826	DD	127189
		DE	2609214		DK	92676	ES	445766
		FI	760576		FI	803150	FR	2315489
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		SE	7603014		SE	7907937	US	4172744
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US	4172744		SEE US 4107376					
GB	1158591	BE	684063		CH	500143	DE	1609793
		GB	1158592		IL	26137		
WO	01/72863	AU	200149453					
EP	224945	DK	517786					
EP	942107	DE	19809973					
WO	94/24226	AT	156180		CA	2160226	DE	4311794
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